Table 1

Frequency of food item occurrence in fecal samples of *Prophysaon coeruleum* and *Prophysaon dubium*. (Total # of samples and % of samples containing item).

	Prophysaon coeruleum						*Prophysaon dubium*					
Single food item	Spring (n = 34)		Fall (n = 52)		Spring and fall (n = 86)		Spring (n = 20)		Fall (n = 37)		Spring and fall (n = 57)	
Plant tissue	25	74%	26	50%	51	59%	14	74%	26	59%	40	63%
Lichens	0	0	13	25%	13	15%	2	10%	8	18%	10	16%
Imperfect fungi	4	12%	6	12%	10	12%	5	26%	4	9%	9	14%
Fungal hyphae*	25	74%	42	81%	67	78%	11	58%	32	73%	43	68%
Fungal spores*	8	24%	32	62%	40	47%	1	5%	37	84%	38	60%
Unidentified	0	0	2	4%	2	2%	2	10%	1	8%	3	5%

* Data does not include imperfect fungi.

predominantly Douglas fir timber stands ranging in age from 50 years to over 200 years old with average tree diameters at breast height (DBH) of 50 cm to over 100 cm. The majority of fecal samples were collected from slugs located in stands over 80 years of age. Surveys were done during the spring and fall when the forest litter layer was moist and the ambient air temperature was between 4°C and 11°C. The established protocol for Survey and Manage terrestrial mollusks (Furnish et al., 1997) was followed. Time-constrained surveys were conducted in suitable habitat with emphasis on suspected areas of high-quality habitat. Two 81 m^2 plots in every 4 hectares of project area, specifically located in high-quality habitat, were intensively searched for 20 minutes each. Another 20 minutes was spent at other sites throughout the remainder of the 4 ha conducting brief, 1–5 minute opportunistic searches.

Specimens of either *P. coeruleum* and *P. dubium* were placed individually in clean, white film canisters until they produced fecal pellets (typically within 1–4 hours). Fecal pellets from individual animals were taken as they were produced from the animal or were collected where they fell on the surfaces of the canisters. No substrate or plant material from the discovery site was placed in the canister with the animal. Fecal pellets were removed from the canisters and immediately placed in a vial of 70% isopropyl alcohol. The animals were returned to the site of collection or kept as vouchers. Identification of slug species was done by examination of external physical characteristics only. Only specimens which conformed to the described species were used in this study. Voucher specimens currently reside at the Roseburg, Oregon Field Office of the Bureau of Land Management.

For fecal analysis, pellets were moved to small vials of 50% ethanol to dissolve lipid layers of viruses which might pose health threats to humans (Colgan et al., 1997). One to two drops of distilled water were then added to rehydrate the samples for 48 hours at room temperature. Pellets were macerated and mixed thoroughly. The resulting suspension was transferred to a microscope slide. One to two drops of Melzer's reagent (iodine, potassium iodide, and chloral hydrate in aqueous solution) were added and the suspension then covered with a 22 × 22 mm cover slip. One slide was made per sample. Seventy-five fields, each 450 μm in diameter, across three horizontal lines of view were then examined on each slide at 250× magnification with a compound microscope. Fungal spores were identified to family, genus, or species according to Castellano et al. (1989). Plant material, lichens, molds, fungal hyphae, and other fungal structures, as well as occasional arthropod fragments and nematodes, were recorded.

Quantitative analysis of the frequency of detections of ingested material was not the intended focus of this study, and the methods used were not quantitatively rigorous. For instance, fecal pellets were not equal in volume, resulting in unequal dilutions in slide preparations. However, an apparent difference was observed in the proportions of fungal and plant material detected in spring samples as compared to fall samples. We investigated this trend using Chi-square tests to detect significant differences ($a = 0.05$) in the frequency of the types of materials identified between fall and spring seasons, and between slug species within seasons. No significance tests were done on the fungal taxa due to the small sample sizes within several fungal taxa.

Results and Discussion

Both *Prophysaon* species in this study showed evidence of consumption of fungi (spores or hyphae of mushrooms or truffles), vascular plant material (both root tissue and other plant tissue), lichens, and imperfect fungi, i.e., molds in their fecal samples (Table 1). Fungi were the most common items found in both *P. coeruleum* 90% (77/86) and *P. dubium* 82% (47/57) samples, with spores from 10 separate fungal families identified. In addition, fragments of arthropods were found in 8% (11/143) of the samples, and nematodes were found in 6% (8/143) of the samples. Nematodes were seen to be whole and in

Table 2

Summary of fungal spore frequency in fecal samples of *Prophysaon coeruleum* and *Prophysaon dubium*.

Fungal spore identity	*Prophysaon coeruleum*				*Prophysaon dubium*			
	Spring (n = 35)		Fall (n = 59)		Spring (n = 19)		Fall (n = 63)	
Subclass: Ascomycotina*	1	3%	5	8%	1	5%	4	6%
order: Tuberales	1	3%	5	8%	1	5%	4	6%
family: Tuberaceae	1	3%	5	8%	1	5%	4	6%
genus: *Genea*	0	0	4	7%	0	0	3	5%
Hydnotrya	0	0	0	0	1	5%	0	0
Pachyphloeus	0	0	1	2%	0	0	0	0
Tuber	1	3%	0	0	0	0	1	2%
Subclass: Basidiomycotina	6	17%	27	46%	0	0	30	48%
order: Ramariales	0	0	1	2%	0	0	1	2%
family: Ramariaceae	0	0	1	2%	0	0	1	2%
genus: *Gautieria*	0	0	1	2%	0	0	1	2%
order: Agaricales	6	17%	26	44%	0	0	29	46%
family: Bolbitiaceae	2	6%	5	8%	0	0	7	11%
family: Boletaceae	2	6%	5	8%	0	0	7	11%
genus: *Melanogaster*	2	6%	3	5%	0	0	5	8%
family: Rhizopogonaceae	2	6%	6	10%	0	0	3	5%
genus: *Rhizopogon*	2	6%	6	10%	0	0	3	5%
family: Coprinaceae	0	0	1	2%	0	0	1	2%
family: Cortinariaceae	0	0	5	8%	0	0	5	8%
genus: *Hymenogaster*	0	0	0	0	0	0	1	2%
family: Entolomataceae	1	3%	0	0	0	0	0	0
family: Russulaceae	1	3%	4	7%	0	0	6	10%
genus: *Gymnomyces*	1	3%	4	7%	0	0	6	10%
Subclass: Zygomycotina	1	3%	2	3%	0	0	0	0
order: Glomales	1	3%	2	3%	0	0	0	0
family: Glomaceae	1	3%	2	3%	0	0	0	0
genus: *Glomus*	1	3%	1	2%	0	0	0	0
genus: *Sclerocystis*	0	0	1	2%	0	0	0	0

* Numbers given for a subclass, order, or family include both specimens identified to genus as well as those identified only to their respective family or order.

good condition, suggesting that they were internal parasites rather than food items. There was no evidence indicating that *P. coeruleum* and *P. dubium* had different diets at this level of resolution.

While acknowledging that the methods used were not quantitatively rigorous, the data suggest a shift in the diet of both species between spring and fall (Table 1). Both species appear to ingest plant material more frequently in spring than in fall. Fungal hyphae, spores, and lichens were more frequently consumed in fall than spring. Chi-square analysis indicates that *P. coeruleum* had significantly more plant material in its fecal samples in the spring than in the fall ($\chi^2 = 4.716$, df = 1, $P = 0.030$), but had more lichens ($\chi^2 = 10.014$, df = 1, $P = 0.002$) and fungal spores ($\chi^2 = 11.938$, df = 1, $P = 0.001$) in the fall than in the spring. *P. dubium* samples had significantly more spores in the fall than in the spring ($\chi^2 = 22.185$, df = 1, $P < 0.001$).

Spores from taxa in the order Agaricales were most commonly recorded. Most of the fungal spores identified (Table 2) were from mycorrhizal taxa that are root symbionts with vascular plants (including many conifer species) and whose hyphae are attached to the rootlets of such plants. In addition, most of the samples with fungal spores identified were of hypogeous fungal species (49/78). The term hypogeous, as used here, includes those species with fruiting bodies occurring within the forest duff layer as well as in mineral soil, such as truffles. All of the other epigeous spore species identified are in the order Agaricales. Twenty-five of the 29 samples containing epigeous fungal spores were collected in the fall, which may help to account for the increased proportion of fungal material in fall samples.

Fungal and vascular plant material appear both separately and together in individual fecal samples. We identified plant tissue composed of root cells and also green plant tissue containing chloroplasts and amyloid granules. Green plant matter was present in the absence of fungal material in 10% (14/143) of the samples, but root tissue was never observed in samples that did not contain fungal hyphae. Fungal material was observed in the absence of plant matter in 37% (53/143). Both plant tissue and fun-

gal tissue were found together in 52% (75/143) of the samples.

These slug species are commonly observed in the forest floor litter layer or associated with coarse woody debris into which conifer roots commonly penetrate. We hypothesize that due to the intimate connections of mycorrhizal hyphae with plant rootlets, root material may have been ingested during the process of foraging for these fungal hyphae. Green plant matter may have been ingested either due to its intrinsic food value or due to the presence of bacteria or yeasts on the surfaces of decomposing material. The presence of spores in 55% (78/143) of the fecal samples suggests that fungal fruiting bodies were being deliberately targeted because these structures are not typically closely associated with plant roots. Fecal pellets collected from four other mollusk species, i.e., *Ariolimax columbianus* (Gould, 1851), *Prophysaon andersoni* (Cooper, 1872), *Prophysaon vannattae* (Pilsbry, 1948), and *Megomphix hemphilli* (Binney, 1879) also evidenced ingestion of both plant and fungal material.

The relative importance of plant, fungal, and other material in the diets of these two slug species warrants further investigation; however, *P. coeruleum* and *P. dubium* in this region are clearly at least partially mycophagous, and especially so in the fall. Most of the fungal species identified are mycorrhizal and hypogeous. Fungal fruiting bodies seemed to be targeted as food items, however fungal hyphae were also present in most samples. Spores seemed to be in good condition, and these slug species may be important vectors for spore dispersal of these forest fungi (Kimmerer & Young, 1995). Future viability studies on the hyphal fragments in mollusk fecal pellets may indicate that dispersal of live hyphae may also be occurring.

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The Taxonomic Status of the Freshwater Snail *Antillobia margalefi* Altaba, 1993, from Hispaniola (Hydrobiidae: Cochliopinae)

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A recent paper (Altaba, 1993) described a freshwater snail from Lago de Enriquillo, Dominican Republic, as *Antillobia margalefi*, new genus and new species. The description is based on "very few specimens," of which two males and two females were dissected. The specimens were preserved unrelaxed in the field in 10% formalin and later transferred to 70% ethanol. They were highly contracted and distorted within their shells because of how they were preserved. The holotype and two figured paratypes were deposited in the Museu de la Naturalesa de les Illes Balears, Ciutat de Mallorca. A third figured paratype remained in the author's collection. Other uncited and unfigured paratypes were said to be in the Florida Museum of Natural History, but they cannot be located.

Altaba (1993) used 27 character-states to compare *Antillobia* with three closely related genera, *Spurwinkia* Davis, Mazurkiewicz & Mandracchia, 1982, *Heleobia* Stimpson, 1865, and *Heleobops* Thompson, 1968 (Cochliopinae) and with the distantly related genus *Hydrobia* Hartmann, 1821 (Hydrobinae). Anatomical data for the four genera were taken from the literature, and were based on abundant specimens that had been properly relaxed and fixed prior to preservation. The 27 character-states are as follows.

1. Hypertrophied ciliation of left tentacle simple (0), grouped in transversal bands (1), or forming subdivided transversal bands (2).
2. Mantle edge with (0) or without (1) pallial tentacle.

3. Osphradium annular (0) or voluted (1).
4. Posterior caecum of stomach deep and bent laterally (0), or median and shallow (1), or altogether absent (2).
5. Typhosole **d** and the dorsal groove it defines absent (0) or present (1).
6. Opening of anterior digestive gland absent (0), anterior (1), posterior (2), or fused with that of posterior digestive gland (3).
7. Gastric shield small (0) or large (1).
8. Ovary lobes few and wide (0), or few globose (1), or several wide (2), or numerous digitiform (3).
9. Anterior end of ovary covering stomach (0) or posterior to it (1).
10. Posterior end of ovary reaching close to posterior end of body (0), or placed far from it (1).
11. Ovary entering ventral sperm canal (0) or posterior pallial oviduct (1).
12. Oviduct coiled (0), or just bent over itself (1).
13. Pallial oviduct divided into two (0) or three (1) distinct regions.
14. Albumen gland straight (0) or bent on itself (1).
15. Lobes of albumen gland small (0), or large and columnar (1).
16. Spermathecal duct absent (0) or present (1).
17. Spermathecal duct coalesced with (1) or independent of (2) oviduct.
18. Spermathecal duct long (1) or short (2).
19. Duct of seminal receptacle stemming off of oviduct (0), connected to it by a short sperm duct (1), or through a simple orifice where they are oppressed (3).
20. Uneverted penis straight (0) or coiled (1).
21. Terminal papilla on the verge simple (0) or eversible (1).
22. Surface of verge smooth (0), or creased and glandular (1).
23. Globose glands on convex side of verge absent (0) or present (1).
24. Stalked glands on convex side of verge absent (0), short (1), or cuplike (2).
25. Anterior concave side of verge with a non-glandular lobe (0), or with a lobe carrying discrete glands along its edge (1), or with a lobe of glandular tissue (2), or without such a lobe (3).
26. Subterminal ciliation on the verge present (0) or absent (1).
27. Longitudinal groove on verge absent (0) or present (1).

Six of the character-states used by Altaba are non-variable within the four cochliopine genera and have no comparative value except to separate the Cochliopinae from the Hydrobiinae. These are character-states 2, 5, 7, 11, 13, and 16.

Eight character-states also have little comparative value because of the manner in which the specimens were preserved and how these character-states were interpreted. For example, the head is illustrated as though it were in a natural relaxed condition (Altalba: 1993, fig. 3), yet if the specimens had been killed unrelaxed in formalin, the head and tentacles would have been severely contracted. Surely the head as illustrated is an interpretation and not an actual depiction. Interpretations of eight character-states used to separate *Antillobia* from *Heleobops* are questionable for the same reason. These include: (3) the shape of the osphradium, (4) the size and shape of the posterior caecum of the stomach, (6) the opening of the digestive gland, (14) the shape of the albumen gland, (22) the texture of the penis surface, and (24) having unstalked or weakly stalked glands along the convex side of the penis. *Antillobia* is described as having discrete glands along the anterior concave side of verge (25), The depiction of these structures in Altabla: 1993, fig. 9 is non-convincing as glands and not as contracted folds of skin. *Antillobia* is said to have a longitudinal groove on [the dorsal surface of] the penis (27). This also is an artifact of preservation due to intense contraction and partial desiccation of the animals caused by having been killed and fixed in formalin.

Five character-states pair *Antillobia* with *Heleobops*, and separate the two from *Spurwinkia* and *Heleobia*. These are: the ciliation pattern on the tentacles (1-1), the anterior extent of the ovary over the stomach (9-1), the weak coiling of the oviduct (12-1), the short spermathecal duct (19-2), and the presence of globose glands along the convex side of the verge (23-1).

Five-character states group *Antillobia* and *Heleobops* with *Heleobia*, and separate the three from *Spurwinkia*. These are: the independent spermathecal duct from the oviduct (17-2), the short spermathecal duct (18-2), the coiled uneverted penis (20-1), the simple terminal papilla on the verge (21-0), and the absence of subterminal ciliation on the verge (26-1).

Three character-states are left to separate *Antillobia* from *Heleobops*. These are (8) the size and number of the ovary lobes, (10) the location of the ovary within the digestive gland, and (15) the size and shape of the albumen gland lobes. These three characters hardly constitute a basis for separating genera, especially considering that the data are based only on two inadequately preserved specimens.

Two taxonomic questions are posed by the description of *Antillobia margalefi*. One question is the status of the genus name *Antillobia*, and the other question is the status of the species name *margalefi*. The description and illustrations given for *Antillobia* pertain to two previously known species, *Pyrgophorus coronatus bermudezi* (Aguayo, 1947) and *Heleobops clytus* Thompson & Hershler, 1991. Both are common species about Lago de Enriquillo, and they are the only two hydrobiids known to occur there. *Heleobops clytus* is oviparous with the uterus unmodified into a brood pouch, and the verge (penis) bears unstalked apocrine glands along its outer curvature. *Pyrgophorus coronatus bermudezi* is viviparous, with a brood-pouch containing developing juveniles, and the verge bears elongate papillae along the outer curvature and elsewhere, as is typical for *Pyrgophorus* (Hershler & Thompson, 1992:90–91). The female reproductive anatomy of *Antillobia*, as described and figured by Altaba, lacks a brood pouch with developing embryos and juveniles (Altaba, 1993, fig. 4), as is typical for *Heleobops*.